

N and C Stocks and $\delta^{13}\text{C}$ of Soil Organic Matter of a Rehabilitated Mined Area

Douglas M. Cavalcante¹, Marllon M. Castro¹, Ivo R. Silva¹, and Teogenes S. Oliveira^{1*}

¹Soil Department, Federal University of Viçosa, Viçosa, Minas Gerais, 36570-900, Brazil. *teo@ufv.br

I. Abstract

The process of rehabilitation after mining operations allows restoration of physical, chemical and biological properties of the soil. The aim of the present study was to evaluate soil organic matter fractions (SOM) under methods of rehabilitation of an area mined using various intercropped plants and types of fertilizer. Soil samples were collected from the 0 – 20 cm layer of an area under four different methods of fertilization: no fertilization (NF), organic (OF), chemical (CF) and organic + chemical (OF + CF), and three types of ground cover in the rows between the coffee: no plants (NP), brachiaria grass (B) and stylosanthes (S). Stocks were evaluated of the total organic carbon and nitrogen (TOC and TN), labile organic carbon and nitrogen (LOC and LN), free light organic matter (C-LOM_L and N-LOM_L), occluded light organic matter (C-LOM_O and N-LOM_O), coarse and fine particulate organic matter (C-POM_c, C-POM_f, N-POM_c and N-POM_f) and mineral-associated organic matter (C-MOM and N-MOM), as well as the isotopic composition of C ($\delta^{13}\text{C}$) and the carbon management index (CMI). The C-LOM_L and N-LOM_L were the most sensitive to the management systems used in the rehabilitation of the mined area. The $\delta^{13}\text{C}$ of MOP_c, MOP_f and MOM, demonstrated that the original stocks of soil carbon in the pre-mining phase had been preserved, showing these fractions to be indicators of soil quality, sensitive to changes resulting from the adopted management, and which contribute to the resilience of the edaphic environment. Generally, applying fertilizer (OF, OF + CF and OF) contributed to a better development of the plants in the rows between the coffee plants, especially the organic + chemical fertilizer (OF + CF), and mainly when applied to the areas where the coffee was intercropped with brachiaria grass, providing higher stocks of carbon and nitrogen and soil organic matter compartments.

II. Results

Table 1. Organic C and N stocks, and carbon management index (CMI) from soils (0-20 cm) under natural vegetation (NV) and ground cover plants in the rows of coffee with different fertilization after bauxite mining.

Methods of fertilisation	Ground cover				Ground cover			
	NP	B	S	Average	NP	B	S	Average
	TOC (t ha⁻¹)				TN (t ha⁻¹)			
Natural vegetation	133,46 ± 12,00				10,90 ± 1,64			
NF	25,37	33,83	28,54	29,25 B	1,77	2,19	1,88	1,95 B
OF	28,69	39,90	37,11	35,23 AB	2,18	2,79	2,65	2,54 AB
CF	31,08	38,65	36,45	35,39 AB	1,88	2,45	2,31	2,21 AB
OF+CF	38,03	45,14	36,17	39,78 A	2,57	3,04	2,49	2,70 A
Average	30,79 b	39,38 a	34,57 b	34,91 ± 2,5	2,10 b	2,62 a	2,33 ab	2,35 ± 0,2
	C:N				LOC (t ha⁻¹)			
Natural vegetation	12,25 ± 0,78				8,85 ± 0,53			
NF	14,32	15,42	15,18	14,97 AB	1,32	1,71	1,61	1,55 A
OF	13,18	14,30	14,00	13,83 B	1,39	2,55	1,94	1,96 A
CF	16,52	15,76	15,80	16,03 A	1,78	2,54	1,89	2,07 A
OF+CF	14,79	14,85	14,53	14,72 AB	2,08	2,93	2,00	2,34 A
Average	14,70 a	15,08 a	14,88 a	14,89 ± 0,4	1,64 b	2,44 a	1,86 b	1,98 ± 0,2
	LN (t ha⁻¹)				CMI (%)			
Natural vegetation	0,275 ± 0,034				100,00 ± 0,00			
NF	0,067	0,071	0,064	0,07 B	14,65	19,06	17,96	17,22 A
OF	0,078	0,099	0,096	0,09 AB	15,47	28,76	21,63	21,95 A
CF	0,078	0,103	0,071	0,08 AB	19,96	28,71	21,00	23,22 A
OF+CF	0,110	0,110	0,096	0,10 A	23,25	33,12	22,31	26,23 A
Average	0,083 a	0,096 a	0,081 a	0,09 ± 0,007	18,33 b	27,41 a	20,73 b	22,16 ± 2,00

Table 3. C stocks of organic matter fractions from soils (0-20 cm) under natural vegetation (NV) and ground cover plants in the rows of coffee with different fertilization after bauxite mining.

Fractions	Methods of fertilisation	Ground cover			
		NP	B	S	Average
		(kg ha⁻¹)			
	Natural vegetation	9,348 ± 2,176			
C-LOM+POM	NF	3,163 Aa	3,649 Aa	3,861 Aa	3,558
	OF	3,731 Aa	4,281 Aa	3,486 Aa	3,833
	CF	2,739 Aab	4,380 Aa	2,155 Ab	3,091
	OF+CF	3,087 Aab	4,725 Aa	2,327 Ab	3,380
	Average	3,180	4,259	2,957	3,465 ± 248,86
	Natural vegetation	171,88 ± 244,24			
C-LOM _L	NF	3,50 Aa	60,42 Ba	18,38 Aa	27,43
	OF	10,53 Ab	149,45 Aa	45,08 Ab	68,35
	CF	3,55 Ab	172,36 Aa	23,10 Ab	66,34
	OF+CF	8,76 Aa	36,40 Ba	16,71 Aa	20,62
	Average	6,59	104,66	25,82	46,69 ± 21,69
	Natural vegetation	10,72 ± 8,55			
C-LOM _O	NF	0,005 Aa	0,008 Ba	0,004 Aa	0,006
	OF	0,005 Ab	0,089 Aa	0,004 Ab	0,033
	CF	0,001 Aa	0,011 Aa	0,020 Aa	0,011
	OF+CF	0,001 Aa	0,004 Ba	0,003 Aa	0,003
	Average	0,003	0,028	0,008	0,013 ± 0,008
	Natural vegetation	3004 ± 380			
C-POM _c	NF	383 Aa	439 Ba	385 Aa	402
	OF	650 Aab	904 Aab	321 Ab	625
	CF	292 Aa	626 Aab	501 Aa	473
	OF+CF	522 Ab	1185 Aa	210 Ab	639
	Average	462	789	354	535 ± 96
	Natural vegetation	6,161 ± 2,233			
C-POM _f	NF	2,777 Aa	3,149 Aa	3,458 Aa	3,128
	OF	3,070 Aa	3,228 Aa	3,121 Aa	3,140
	CF	2,443 Aab	3,581 Aa	1,631 Bb	2,552
	OF+CF	2,556 Aa	3,504 Aa	2,100 Aa	2,720
	Average	2,712	3,365	2,577	2,885 ± 199
	Natural vegetation	124,113 ± 11,312			
C-MOM	NF	22,206 Ba	30,184 Aa	24,679 Aa	25,690
	OF	24,957 ABb	35,623 Aa	33,707 Aab	31,429
	CF	28,344 Aab	34,422 Aa	34,425 Aa	32,397
	OF+CF	34,941 Aa	40,714 Aa	33,835 Aa	36,497
	Average	27,612	35,236	31,661	31,503 ± 2,390

Table 2. Isotopic composition of C ($\delta^{13}\text{C}$) and contribution of C from C3 or C4 plants on organic fractions from soils (0-20 cm) under natural vegetation (NV) and ground cover plants in the rows of coffee with different fertilization after bauxite mining.

Fractions	Treatments	$\delta^{13}\text{C}$	C derived from C3 plants		C derived from C4 plants	
			%	%	%	%
LOM _L	Natural vegetation	-23,97	-	-	-	-
	Coffee NF/NP	-22,05	83,92	16,08	16,08	16,08
	Coffee NF/B	-16,43	37,02	62,98	62,98	62,98
	Coffee NF/S	-23,40	95,22	4,78	4,78	4,78
	Coffee OF+CF/NP	-20,93	74,56	25,44	25,44	25,44
POM _c	Natural vegetation	-23,94	-	-	-	-
	Coffee NF/NP	-20,69	72,78	27,22	27,22	27,22
	Coffee NF/B	-19,75	64,91	35,09	35,09	35,09
	Coffee NF/S	-21,56	80,04	19,96	19,96	19,96
	Coffee OF+CF/NP	-16,06	34,02	65,98	65,98	65,98
POM _f	Natural vegetation	-23,79	-	-	-	-
	Coffee NF/NP	-21,59	81,38	18,62	18,62	18,62
	Coffee NF/B	-20,03	68,12	31,88	31,88	31,88
	Coffee NF/S	-20,54	72,43	27,57	27,57	27,57
	Coffee OF+CF/NP	-19,36	62,46	37,54	37,54	37,54
MOM	Natural vegetation	-23,63	-	-	-	-
	Coffee NF/NP	-20,38	72,10	27,90	27,90	27,90
	Coffee NF/B	-20,17	70,28	29,72	29,72	29,72
	Coffee NF/S	-20,82	75,85	24,15	24,15	24,15
	Coffee OF+CF/NP	-20,35	71,83	28,17	28,17	28,17

Table 4. N stocks of organic matter fractions from soils (0-20 cm) under natural vegetation (NV) and ground cover plants in the rows of coffee with different fertilization after bauxite mining.

Fractions	Methods of fertilisation	Ground cover			Average
		NP	B	S	
		(kg ha⁻¹)			
	Natural vegetation	476,47 ± 202,15			
N-LOM+POM	NF	50,69 Aa	68,42 Aa	59,16 Aa	59,42
	OF	70,84 Aa	128,09 Aa	88,53 Aa	95,82
	CF	55,58 Ab	128,18 Aa	49,94 Ab	77,90
	OF+CF	123,23 Aa	124,09 Aa	97,32 Aa	114,88
	Average	75,09	112,19	73,74	87,01 ± 15,18
	Natural vegetation	10,88 ± 16,86			
N-LOM _L	NF	0,14 Aa	1,80 Ba	0,91 Aa	0,95
	OF	0,79 Ab	7,78 Aa	2,65 Ab	3,74
	CF	0,16 Ab	9,02 Aa	1,35 Ab	3,51
	OF+CF	0,53 Aa	1,87 Ba	1,54 Aa	1,31
	Average	0,41	5,12	1,61	2,38 ± 1,39
	Natural vegetation	0,93 ± 0,74			
N-LOM _O	NF	2,69 x10 ⁻⁰⁴ Aa	3,02 x10 ⁻⁰⁴ Ba	2,30 x10 ⁻⁰⁴ Aa	2,67 x10 ⁻⁰⁴
	OF	2,43 x10 ⁻⁰⁴ Ab	4,00 x10 ⁻⁰⁴ Aa	1,92 x10 ⁻⁰⁴ Ab	1,48 x10 ⁻⁰³
	CF	7,94 x10 ⁻⁰⁵ Aa	7,46 x10 ⁻⁰⁴ Aa	6,70 x10 ⁻⁰⁴ Aa	4,75 x10 ⁻⁰⁴
	OF+CF	7,35 x10 ⁻⁰⁵ Aa	1,59 x10 ⁻⁰⁴ Ba	1,44 x10 ⁻⁰⁴ Aa	1,26 x10 ⁻⁰⁴
	Average	1,48 x10⁻⁰⁴	1,30 x10⁻⁰³	3,09 x10⁻⁰⁴	5,86 x10⁻⁰⁴ ± 5,21 x10⁻⁰⁴
	Natural vegetation	148,34 ± 23,38			
N-POM _c	NF	17,24 Ba	28,69 Aa	19,19 Aa	21,71
	OF	25,55 Aab	46,11 Aa	30,94 Aa	34,20
	CF	19,38 Ba	31,83 Aa	16,44 Aa	22,55
	OF+CF	45,51 Aa	45,56 Aa	36,63 Aa	42,57
	Average	26,92	38,05	25,80	30,26 ± 5,33
	Natural vegetation	217,47 ± 84,48			
N-POM _f	NF	33,30 Aa	37,93 Aa	39,06 Aa	36,76
	OF	44,49 Aa	74,18 Aa	54,93 Aa	57,87
	CF	36,03 Ab	87,33 Aa	32,15 Ab	51,84
	OF+CF	77,19 Aa	76,65 Aa	59,15 Aa	71,00
	Average	47,75	69,02	46,32	54,37 ± 9,49
	Natural vegetation	10,520,38 ± 1,609,25			
N-MOM	NF	1,721,22 Aa	2,126,14 Aa	1,820,88 Aa	1,889,41
	OF	2,106,38 Aa	2,661,83 Aa	2,561,90 Aa	2,443,37
	CF	1,825,39 Aa	2,324,08 Aa	2,256,61 Aa	2,135,36
	OF+CF	2,448,39 Aa	2,914,87 Aa	2,392,45 Aa	2,585,24
	Average	2,025,34	2,506,73	2,257,96	2,263,35 ± 172,51

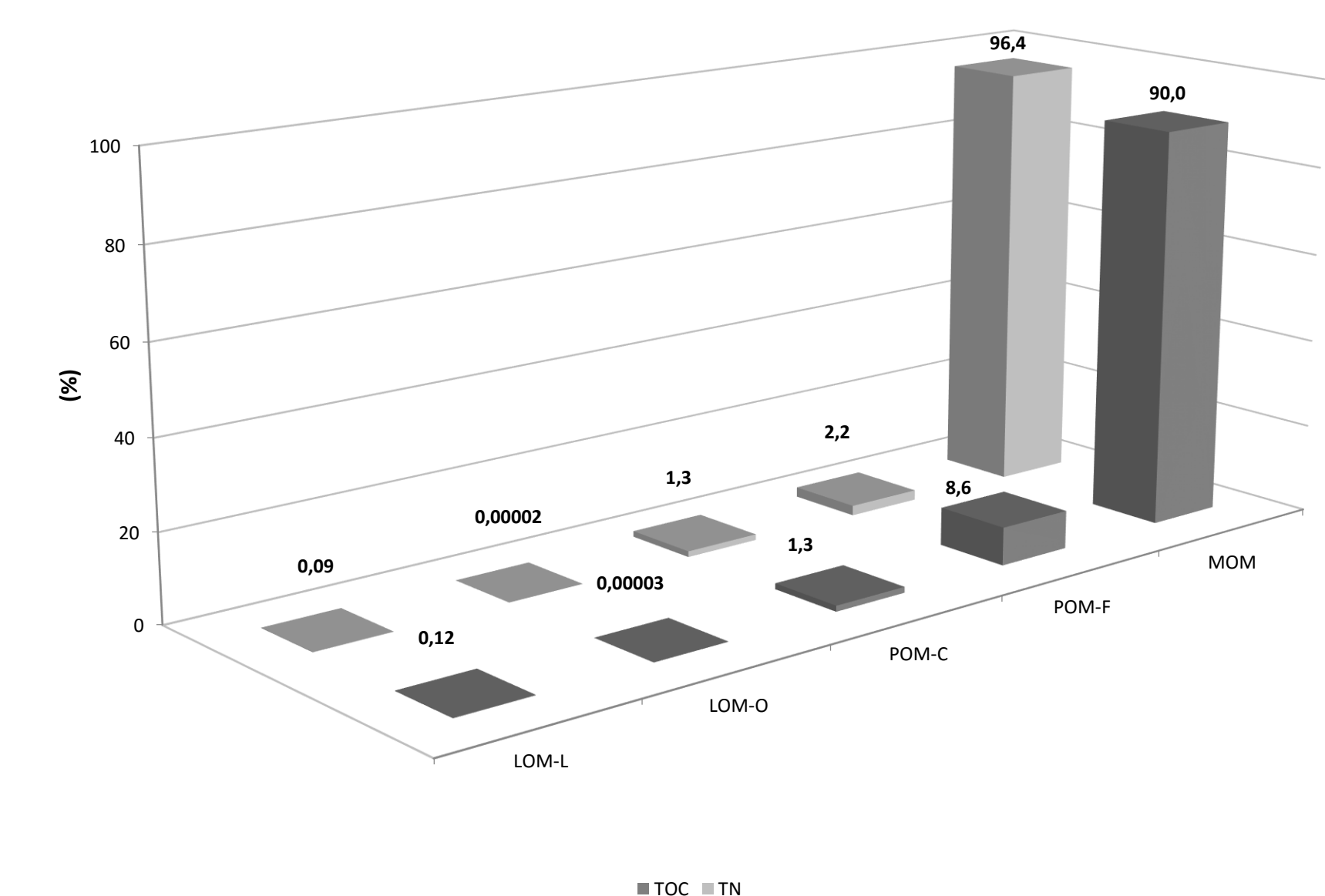


Figure 1. C organic and N proportion of organic matter fractions from soils (0-20 cm) under natural vegetation (NV) and ground cover plants in the rows of coffee with different fertilization after bauxite mining.

